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Part 3

ASH AND SLAG HANDLING

3.5. Applications of ash and slag from power coals

3.5.1. Production of the building materials

3.5.1.1. The Russian standards for using ash and slag from thermal power plants for production of the building materials

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ABSTRACT

The basic standards regulating the demands to composition and properties of fly ash, slag and ash-and-slag mixtures from solid fuel burning at heat power plants and to use in manufacturing of construction materials and building of highways are observed. It is offered to deposit to introduce clarity into standards concerning slags composition extended trends and raising efficiency of their application in building.

INTRODUCTION

On burning bituminous and lignite coals, anthracite, bituminous shale and peat form ashes and the slag being products of high-temperature processing of their mineral part. Practically at all power stations of Russia fuel is burnt in powdered condition at temperature in the boiler from 1300 up to 1700 ºC. During burning solid fuel and depending on a way of trapping and removing the following co-products are formed:

- fly ash – the fine material (the size of particles from 3…5 up to 100…150 microns), forming from a mineral part of powdered fuel, trapped from fuel gases by special devices at power stations;
- slag is an aggregated and fused particles of ash with size from 0,15 to 40 mm;
- ash-and-slag mixture – is a mixture of fly ash and slag formed at their joint removal in ash dump. On burning the fuel in the furnace with solid slag removal 10…20 % of slag is formed, 20…40 % of slag is formed in the furnace with liquid slag removal, slag is not formed in the furnace with fluidized bed, but particles of ash have the size up to 10 mm.

Ash-and-slag materials differ according to their chemical and mineralogical composition, physical properties, fusion temperature, radioactivity and other characteristics due to the wide variety of solid fuel, different conditions of its combustion as well as different ways of its trapping and removing. The main criteria for estimation of possibility to use ash-and-slag materials in building and construction material production are chemical composition, content of combustibles and free calcium oxide, specific surface, melting temperature. Additional characteristics of ash and slag are humidity, grain structure, bulk density, and the maintenance glassy and melted particles of fly ash, viscosity at high temperatures. In addition, it is recommended to use X-ray structure and differential thermal analysis to estimate mineralogical composition of ash-and-slag.

Chemical composition of ash-and-slag material is essential to define the uses in building and construction material production. Fly ash chemical composition differs during the combustion of bituminous and lignite coals within the following ranges, mass %: 21…64 SiO_2, 4…39 $A1_2O_3$, 2…28 Fe_2O_3, 1…46 CaO, 0,2…6 MgO, 0,1…9 SO_3. Content of residual fuel in the fly ash is from 0,5 to 22 %, it does not exceed 1 % in slag.

In accordance with DR 34.09.603–88 chemical composition of ash-and-slag is subdivided into acid (acidity module $M > 1$) and main ($M \leq 1$); fuel content − subdivided into ash-and-slag with low, middle and high content of fuel, accordingly, loss of ignition not more than 5 %, from 5 to 10 % and more than 10 % accordingly; according to its dispersibility – subdivided into low dispersive, middle dispersive and high dispersive ash-and-slag with specific surface less than 150 m^2/kg, from 150 to 300 m^2/kg and more than 300 m^2/kg accordingly; according to the melting temperature – subdivided into low-melt, middle-melting and high-melting with fusion temperature 1250 ºC, from 1250 to 1450 ºC and more than 1450 ºC accordingly [1].

Ash-and-slag physicochemical properties for coal of different grades and fields must meet the requirements of OST 34–70–542–2001 [2]. Concerning the type of burned coal the slag of heat power plants is subdivided into bituminous and lignite slag, according to its average density – subdivided into dense (grain density is higher than 2,000 kg/m^3) which is produced in boiler furnaces with liquid slag removal, and into porous (grain density is not higher than 2,000 kg/m^3), which is produced in boiler furnaces with solid slag removal system [3].

Fly ash and ash-and-slag mixtures of heat power plants′ disposal area can be used for production of different construction materials: cement, lime-and-sand and clay bricks, concrete stone, porous fillers for concretes, bituminous concrete etc. Fuel slag can be used for production of heavy-weight and light-weight concrete, slag glass-ceramic. The requirements to usage of ash-and-slag materials for production of construction materials and products are included in quite a number of normative documents in force: GOST 379–95, GOST 530–2007, GOST 6133–84, GOST 9128–97, GOST 9757–90, GOST 10178–85, GOST 16557–78, GOST 17608–91, GOST 20910–90, GOST 22266–94, GOST 23558–94, GOST 25485–89, GOST 26644–85, GOST 28013–98, GOST 30491–97, GOST 31108–2003 etc.

Russian standards establish requirements for heat power plants fly ash, slag and ash-and-slag mixtures for the usage in different sectors of economy [2-10]. First of all suitableness of ash and slag as the main raw material for production of construction materials and concretes of different purposes as aggregate or partial substitution of binding material is determined by lack or limited content of harmful components which deteriorate physical-mechanical properties of construction material and concretes and reduce their performance properties or hamper technological production processes and limit of application range.

1. CEMENT PRODUCTION

In Russia ash-and-slag materials are frequently used in cement plants as aluminum silicate component of portland cement clinker raw mix and an active mineral admixture during its grinding at the plants which produce cellular concrete and calcium-silicate bricks under the condition that ash-lime cement is produced. In accordance with GOST 10178–85 ash-and-slag can be added to portland cement in amount of 20 %, blast furnace cement − not more than 10 % [11], but to the composition of pozzolanic cement – up to 40 % of the cement mass. Portland cement with the heat power ash differs from the usual portland cement with prolonged strength gain and low-velocity of initial hardening, increased water demand and sulphite resistance, reduced heat generation, shrinkage and swelling deformation, frost resistance.

In accordance with TS 3470–10347–92 there are the following requirements to fly ash, slag and ash-and-slag mixture as the active mineral admixture of raw clinker mixture:

- humidity not more than 15 %;
- specific surface area – not less than 200 m^2/kg;
- in the basic ash the contents of free CaO should not exceed 10 %;
- the contents ion chloride – not more than 0,10 %;
- at use in the capacity of a raw ingredient of a fire loss in ash-slag should be not more than 16 %, the contents in them of alkalis (Na_2O+K_2O) – no more than 4 %, sulphides in conversion on SO_3 – no more than 4 %;
- at use in the capacity of the mineral additive in weight loss cement at an incineration ash-slags there should be no more than 5 %, the contents in them of alkalis (Na_2O+K_2O) – not more than 2 %, in sour and basic ash-slags the contents of sulphides in conversion to SO_3 – no more than 2 and 6 %, accordingly;
- the end of the lime and ash test setting time not later than 7 day;
- water resistance of lime-ash sample after 3 days hardening;
- cement with ash-and-slag must pass the air-test according to GOST 310.3–76 [12].

In accordance with the general-purpose cement standard GOST 31108–2003, harmonized with the standard EN 197–1, fuel fly ash of acid and general composition in portland cement with mineral additives CEM II type in quantity 6…20 %, composition portland cement – not more than 14%, pozzolanic cement CEM IV type – from 21 to 35 % of cement mass can be used as a mineral additive [6]. In addition, fly ash can be used in cement together with other mineral additives as well as an auxiliary component in amount not more than 5 % of cement mass. This standard does not foresee the usage of the waste ash-and-slag mixture and fuel slag as a mineral additive.

GOST 31108–2003 regulates the requirements to general and auxiliary components of cement including requirements to active mineral additives. Heat power fly ash, used as a mineral additive, must satisfy the following composition and property requirements:

- content of reactive SiO_2 in acid ash must be more than 25 %, reactive CaO − not less than 10 %, quantity of free calcium oxide − not more than 1 %. Content of reactive CaO in basic ash must less than 10 %. Under the condition that the quantity of reactive CaO in basic ash is from 10 to 15 %, so the content of reactive SiO_2 must be more than 25 %;
- loss on ignition during 1 hour ignition is not more than 5 %. Fly ash, characterized by the 5 to 7 % mass losses during the ignition, are used on the assumption of satisfaction of the life-time requirements of cement concrete and mortar, especially frost resistance requirements taking into consideration climatic factors of a region they are used in;
- compressive cement strength difference with fly ash and high-silica sand cement (*t*-Student′s criterion) − not less than 2,07;
- the end of setting time of lime-ash test not later than 7 days;
- water resistance of lime-ash stone – not less than 3 days;

Indices of Student *t*-criterion, setting time end of lime-ash test and water resistance of lime-ash stone are defined according to GOST 25094–94 [13].

2. CONCRETE AND MORTAR

Fly ash and ash-and-slag mixtures, produced at heat power plants during combustion of solid fuel, can be used as a mineral admixture which substitutes cement as well as partial and complete substitution of fine aggregate in concrete and mortar mix production. The most effectively fly ash is used for production of low-grade concrete (to B20), namely, for production of concrete which is used for construction of dams, foundations, basements. Quantity of added ash varies from 30 to 90 kg per 1 m^3 of concrete mix.

Quality of heat power fly ash, used for concrete and mortar mix must satisfy requirements of GOST 25818–91 [4], ash-and-slag mixture – GOST 25592–91 [5]. GOST 25818–91 covers the fly ash which is used as a component for heavy, light, cellular concrete and mortar mixes well as fine admixture for heat-resistant concrete and binding material for road construction mixes and ground. The standard does not cover ash which is produced from pyroschist combustion. GOST 25592–91 specifies requirements to heat power ash-and-slag mixes which are used as an aggregate for heavy and light concrete of pre cast and cast concrete structures and reinforced concrete buildings and structures. This standard does not allow using ash-and-slag mixes as an aggregate for concrete of hydraulic structures, road carpet, pipes, crosstie, power transmission line supports and for structures of special concrete.

In accordance with GOST 25818–91 fly ash is subdivided as to the type of the burned coal into anthracite (A), produced from anthracite combustion, semi anthracite and hard coal; bituminous coal (BC), produced from black coal combustion; lignite (L), produced from lignite coal combustion. As to the chemical composition fly ash is subdivided by into the following types: acid (A) – anthracite, bituminous and lignite coal which contain up to 10 % of calcium oxide; basic (B) – lignite coal which contain more than 10 % of CaO. However, such classification does not reflect available features of elemental composition of lignite high CaO content. Therefore, for lignite forms it is necessary to introduce an additional type − high-basic, consisting of CaO more than 40 %.

Fly ash is divided into 4 types depending on qualitative indices: I – for reinforced concrete structures made of heavy and light concrete; II – for concrete structures made of heavy and light concrete, mortar mixes; III – for products and structures made of cellular concrete; IV – for concrete and reinforced concrete products and structures for hydraulic structures, roads, airfields etc.

Fly ash is used for production of heavy and light concrete, mortar mix to reduce the consumption of cement and aggregates, to improve concrete and mortar mix technological properties, to increase the quality of concrete and mortars. Acid ash is to be used for cellular concrete as silicate

component of mortar. Acid ash is used to save cement of nonautoclaved concrete. Basic ash with CaO content over 30 % is recommended for usage as a mineral admixture in cement or component of other binding material for production of structural concrete and mortars, as a binding material for partial substitution of lime or cement of cellular cement of autoclaved and non autoclaved concrete. Acid ash is to be used for structural heat insulating concrete for partial and complete substitution of porous sand and for reduction of concrete density. Acid ash IV type is to be used for underwater and internal areas of hydraulic structures.

Optimum content of ash in heavy, light, cellular concrete and mortar mix is ensured due to batching of specific material on the consumption of obtaining required concrete and mortar quality index of products, structures and corrosion resistance of reinforcement bar. Content of acid ash in concrete must not exceed the mass of portland cement consumption to ensure corrosion resistance of nonprestressed reinforcement bar of reinforcement concrete structures which are used in non-aggressive media. Possibility for increasing ash content in heavy and light concrete is determined after carring out of reinforcement corrosion resistance tests, concrete deformability and durability test.

Qualitative indices of different types of ash for structural concrete and mortar must satisfy the requirements indicated in the Table 1. Ash humidity must be lower than 1 %. Fly ash with portland cement must ensure soundness during sample tests by means of boiling method, basic ash III type – in autoclave.

Fly ash can be used as a binding material and siliceous component for production of cellular concrete. In accordance with GOST 25485–89 general ash with CaO content not less than 40% including free CaO – not less than 16 %, SO_3 – not more than 6 %, the sum of oxides K_2O and Na_2O – not more than 3,5 % can be used as binding material for cellular concrete production [14]. If fly ash is used as siliceous component of concrete mortar it must not contain SiO_2 less than 45 %, CaO over 10 %, K_2O+Na_2O over 3 %, SO_3 over 3 %.

Previously, there were the following requirements to heat power ash in BN 277–80 cellular concrete products manufacturing instruction. Ordinary ash which is produced due to pyroschist and lignite combustion must have the following chemical composition: content of general CaO – not less than 30 %, including free CaO – 15…25 %; content of oxide SiO_2 – 20…30 %, oxide SO_3 – not more than 6 %, sum of oxides K_2O and Na_2O not more 3 % [15]. Fly ash specific surface must be within the range from 300 to 350 m^2/kg.

Acid fly-ash must have glassy and fused particles more than 50 %, accordingly weight loss must be less than 3…5 % during the ignition of bituminous and lignite coal, accordingly specific surface of bituminous and lignite coal must be more than 400 and less than 500 m^2/kg. Fly ash must pass the soundness test.

In accordance with GOST 26644–85 fractional crushed stone with grain size 5–10, 10–20 and 5–20 mm, slag sand with grain size to 5 mm, usual unscreened slag with gain size to 20 mm can be produced due to solid fuel combustion. Requirements to grain distribution of fractional crushed stone, slag sand and usual slag are shown in the Table 2.

Bulk density of crushed stone made of dense slag, used for heavy concrete production, must be more than 1000 kg/m^3, slag sand made of dense slag – more than 1100 kg/m^3. Depending on the density of the crushed stone of the porous slag used for lightweight concrete grades 500, 600, 700, 800, 900 and 1000 are divided, sand – 600, 700, 800, 900, 1000 and 1100 grades.

Weight loss during calcining of solid slag crushed stone and sand is not standardized and in the porous coal and lignite slag they must not exceed the values, respectively, in the use of aggregates in concrete 7 and 3 %, in the reinforced concrete products – 5 and 3 %. Content of sulphurous and sulphite compounds in the re-computation to SO_3 in the slag crushed stone and sand must not exceed 3 % and free CaO – 1 %. Crushed stone must have a stable structure: loss of weight in determining the slag resistance of silica and iron against decay respectively must not exceed 8 and 5 %.

Frost resistance of crushed stone must be characterized by weight loss no more than 8 % at 15 cycles of alternate freezing and thawing for porous crushed stone and 100 cycles for the solid crushed stone. Foreign matters (organic remnant, soil, brick) must not be available in the crushed stone and sand.

Sulphar compounds refer to the harmful components in the composition of ash and slag, unburnt particles of solid fuel (coke and semi-coke) free calcium and magnesium oxides, especially in macrocrystalline and burnt condition, alkaline materials oxides. In addition the availability in mineralogical composition of ash and slag unstable phases causes negative effect, resulted in

Table 1. **Requirements to HPS fly ash for construction concretes and mortars (GOST 25818−91)**

№	Name of the factor	Type of coal	Importance of the factor for type of the ash			
			I	II	III	IV
1	Contents of the calcium oxide, mass %:					
	– acid ash, not more than	For all	10	10	10	10
	– main ash, more than,	Brown	10	10	10	10
	including free CaO, not more:					
	– acid ash	For all	-	-	-	-
	– main ash	Brown	5	5	-	2
2	Contents of the magnesium oxide, mass %, not more	For all	5	5	-	5
3	Contents of the sulfide and tart sulfide compounds in recalculation on SO_3, mass %, not more:					
	– acid ash	For all	3	5	3	3
	– main ash	Brown	5	5	6	3
4	Contents of the alkaline oxides in recalculation Na_2O, mass %, not more:					
	– tart ash	For all	3	3	3	3
	– main ash	Brown	1,5	1,5	3,5	1,5
5	Loss on ignition, mass. %, not more:					
	– acid ash	Blind coal	20	25	10	10
		Coal	10	15	7	5

	– main ash	Brown Brown	3 3	5 5	5 3	2 3
6	Specific surface, m^2/кg, not less: – acid ash – main ash	 For all Brown	 250 250	 150 200	 250 150	 300 300
7	Sieve residue № 008, mass %, not more: – acid ash – main ash	 For all Brown	 20 20	 30 20	 20 30	 15 15

Table 2. **Requirements to grain composition of crushed stone and sand from the slag Heat Power Station**

Name of the factor	Importance of the factor for		
	Fractionated crushed stone	Slag sand	Ordinary unsorted slag
Complete residue on the sieve with diameter of sieve opening's respective to smallest nominal grain size of fractions, mass %	90–100	–	–
Complete residue on the sieve with diameter of sieve opening's respective to the most nominal grain size of fractions, mass %	To 10	To 10	To 10
Content of grains passing through the sieve № 0315, mass %, not more	5	20	10

the destruction of ash particles or slag granules as a result volume changes of the unburnt clay matter, available in the low-temperature combustion slag. Alumina of another variety (dehydrated) is able to rehydration and causes volume changes of slag. Iron sulphides oxidizing under combined effect of air and water harmfully influence on the deformation properties of construction materials and products consisting of ash and slag.

In accordance with GOST 25592–91 of the coal ash and slag mixture HPS used as an aggregate for the heavy and light concretes prefabricated and monolithic concrete and reinforced concrete structures are subject-ted to the following specifications (Table 3) [5]. In addition, weight loss during calcinations for different classes and types of ash-and-slag mixtures should not exceed the values given in Table 4. Additional requirements for the following HPS ash-slag mixture. The total content ash part (less than 0,16 mm) of ash-and-slag mixture of free calcium oxide and magnesium oxide should not exceed 10 %, in the slag − not more 1 %. Ash, in the ash-and-slag mixture, must withstand the test of uniformity of change. Slag with a grain size larger than 5 мм, contained a mixture of ash and slag in the class A (type I and II) and class B (type I) must have a stable structure. Loss weights in determining the slag resistance of it to the silicate and glandular disintegration must not exceed 5 %. Extraneous impurities clog (plant sludge, soil, bricks) must not be available in a mixture of ash and slag. Ash-and-slag mixture with slag contents from 20 to 50 % is allowed to apply for heavy concrete, together with natural filler.

Ash-and-slag mixture from HPS is used in fireproof concrete constitution (with temperature of exploitation up to 1800 °C) for cement economy and for improvement of exploitation properties, as to chemical constitution and dispercity must meet the requirements of GOST 20910–90 [7]. The following requirements exist for ash-and-slag mixture used like a fine-grinding admixture in concrete on portland cement and liquid glass: fineness of grinding must be not less 50 % on passing through the sieve № 008; content of free CaO and MgO together must not exceed 3 %, of carbonates – 2 %.

Table 3. **Requirements to ash-and-slag mixture, used as concrete fillers**

Name of the factor	Meaning of indices for classes	
	А (heavy concrete)	Б (light concrete)
Contents of slag, mass %	Not less 50	To 20
Slag and ash grains content measurements not less 0,315 mm, mass %:		
type I	20−30	50−100
type II	20−50	50−100
Grained content measurements with the size not more 5 mm, mass. %	–	Not more 15
Maximum size of slag grains measurement, mass %	40	20
Specific surface, m^2/кg	–	150−400
Humidity, mass %	Not more 15	Not more 35
Air-dried density, kg/m^3	Not less 1300	Not more 1300
Contents of the sulfide and tart sulfide compounds in recalculation on SO_3, mass %,	Not more 3	Not more 3
including sulphides from	Not more 1	Not more 1
Amount of SiO_2, mass %	Not less 40	Not less 40

Table 4. **Requirements to mass losses of ash-and-slag mixtures**

Class	Type	Mass losses on ignition, mass %, not more		
		Anthracite	Black coal	Brown coal
A	I II	5 10	3 5	2 2
B	I II	15 20	7 10	5 5

In application ash-and-slag mixture as refractory concrete filler its chemical composition must satisfy the following requirements: total SiO_2 and $A1_2O_3$ must be not less 75 % and SiO_2 – not less 40 %; amount sulphite in recalculation on SO_3 – not more 3 %, sum of free CaO and MgO – not more 4 %, mass ignition loss – not more 5 %. Ash-and-slag mixture must not be polluted by other materials capable to lower exploitation properties or to lead to the concrete destruction after heating (limestone, granite, dolomite, magnetite).

3. STRUCTURAL CLAY PRODUCTS

Fly ash and ash-slag mixtures can be used as raw materials for the production of artificial porous fillers for light concrete, ceramic bricks and stone. According to the TS 21–31–2–82 fly ash for production of agloporitovij gravel should meet the following requirements:

- chemical composition should be in the following ranges, mass %: 55±10 SiO_2, 25±10 $A1_2O_3$, 10±8 Fe_2O_3, up to 12 CaO+MgO, up to 3 SO_3;
- weight ignition losses should be not more than 10 % for easily melting ashes, 12 % for medium melting ashes, 15 % for refractory ashes. Fluctuation of values of weight losses in the time of calcining in ash must not exceed than 2 %;
- specific surface − not more than 200 m^2/kg [9].

Fly ash used for production of ceramic bricks and stones must satisfy to the following requirements:

- content of carbonate stone like inclusions larger than 1 mm − is not admitted;
- content of slag inclusions larger than 3 mm − is not more than 5 %;
- content of sulphurous in recalculation on SO_3 − is not more than 3 %.

In manufacture of flay ash claydite it is recommended to use ash of hydroremoval from disposal area HPS which should meet the following requirements:

- for claydite with the low density: loss ignition − 13…17 %, the content Fe_2O_3+FeO − 12…20 %, total CaO − 7…12 %, the limiting size of slag and vegetative inclusions − 5 mm, content of particles more than 1 mm − less than 10 %, specific surface − 100…300 m^2/kg;
- for claydite with the high density: loss ignition is not more 5 %, the content $A1_2O_3$ 20…35 %, total CaO − 7…12 %, specific surface is more 300 m^2/kg, the melting temperature of ash is more 1370 ºC [16].

4. CONSTRUCTION OF AUTOMOBILE ROADS

For construction of automobile road flyashes from heat power are used for organize forced road base and coating as active hydraulic addition i.e. active component of composite binder in aggregate cement or lime as single slow setting binder and ash-and-slag mixtures from dumps HPS – as material for construction dumps of road beds and low active hydraulic component in aggregate with cement for strengthening of soil on III−V categories roads.

Reasonability of applying fly ash and ash-and-slag mixtures is established in each one case on the base of feasibility from the point of quality ash-and-slag materials view, distance of the transportation and costs, economy of the cement and other factors. Evaluation indication of availability ash-and-slag materials for construction of the foundation of road bed is frost resistance characterized with the scale of relative freeze rebound, corresponding to the relation of vertical deformation of swelling under frosting of the sample to it's initial high.

Ash-and-slag mixtures and fly ash being used for erection of road embankment must guarantee to the latter essential stability and strength. They are classified depending on frost-resistance: not swelling – less than 1 %, poorly swelling – 1…3 %; swelling – 3…10 %; very swelling – more than 10 % [10]. Ash-and-slag materials, which have value of relative freeze swelling not more that 3 % are used for erection of road embankment without limitation; the value of freeze swelling from 3 to 10 %, it allows for filling of earth embankment with obligatory realizing of package of securing of its stability. Ash-and-slag mixtures with value of relative freeze swelling more than 10 % aren't used for erection of earth embankment.

Used for stabilization soil in the capacity of independent binding or active component of mixed binding fly ashes from burning brown and black coal, peat and shale on thermal power plants are needed to select directly from electrostatic collectors or cyclone and satisfy the next requirements (Table 5). Content of sulphite and sulphite compounds in fly ashes of pyroshale used as independent low-early-strength binding is permitted as an exception in the quantity not more than 10 %. Fly ash in content of mixed binding (20…30 % of cement and 70…80 % of ash) are under test on volumetric change uniformity.

It is admitted fly ash applying with specific surface is not less 160 m^2/kg on the roads of III–V categories at arrangement the basis of road coatings and covers on the roads of only IV–V categories if the contents of free lime oxide, sulphurous and sulfate weight ignition losses correspond to the requirements pointed out. The content of free lime oxide is admitted not less 15 % but on strengthening by cement of sand and sandy soils and it is allowed fly ash and ash-and-slag mixtures to be used which do not meet the requirements in Table 5. According to this fly ashes and fly-slag mixtures have to contain more 60 % particles the size of which is less 0,071 mm no more than 5 % of coarse particles a size are larger 2 mm, and weight losses on ignition − no more than 10 %. Specific surface of slate ash for machining of soils on building the foundations of pavements on roads II−III of classes should be not less than 200 m^2/kg. On building the foundation bases on roads of IV−V grades or frost-protecting layers and roadbed top layers on roads of all grades shale ash with a specific surface area not less than 120 m^2/kg can be used.

Fly ash and ash-slag mixtures of heat power-stations can be used also in the capacity of mineral powders as a part of a porous, high-porous and dense asphaltic concrete II and III grades [17]. Thus, they should meet the following demands:

- grain content, not less: fraction less than 1,25 mm – 95 %, fraction less than 0,315 mm – 80 %, fraction less than 0,071 mm – 60 %;
- hollowness – not more than 45 %;
- water stability of samples from a mixture ash-slags with bitumen – not less than 0,6;
- a parameter bitumen-reservoir – not more than 100 g;
- loss on ignition – not more than 20 %;
- the contents active CaO+MgO – not more than 3 %;
- the contents of the water-soluble compounds – no more than 6 %.

Table 5. **Requirements to fly ashes of heat power-stations for use at building of highways**

Rationed parameters	Requirements to fly ash		
	Independent slowly-hardening the binding	Active component blended binding with	
		cement	lime
The contents of free CaO, mass %	Not less 8	Not more 4	−
Specific surface area, m^2/kg	Not less 300		
The contents of sulphurous and sulphite bridging's (in conversion on SO_3), mass %	Not more 6	Not more 3	−
Loss on ignition, mass %	Not more 5	Not more 10	Not more 10

RADIATION SAFETY ASH-SLAG

Fly ash, slag and ash-and-slag mixtures of heat power engineering depending on magnitude of depending on magnitude of the total specific effective activity of natural radionuclide's (A_{eff}) can be applied in manufacturing of materials, items and the constructions used for building and redesign inhabited and public buildings and applied to building of process buildings (A_{eff} up to 370 Bk/kg) and constructions, and also road constructions within territories of human settlements and working areas of a long-range building (A_{eff} = 370…740 Bk/kg) [3-5].

SUMMARY

Standards applied in Russia to fly ash, slag and ash-and-slag mixture to heat power engineering regulate demands to key properties and consider features of their elemental composition in use in production of construction materials and construction of highways. For more effective application of brown coal fly ashes it is suggested to introduce an additional types the high-basic ashes. Besides it is expedient to consider the problem concerning the permissible increase of the residual fuel content from high temperature burning of anthracites with due regard for trends of their application in building.

REFERENCES

1. **RD 34.9.603−88**. Methodical directions for of the organization of the check of makeup and properties of ash and the slags, released to users heat power plants. From 01.01.1989. M.: WTI, 1988.
2. **OST 34−70−542−2001**. The Fly ash of heat power plants. Standard performances. From 01.07.2001. M.: Open Company «WTI», 2001.
3. **GOST 26644−85**. Rubble and sand from slags of heat power plants for concrete. Standard specifications. From 01.01.1987. M.: Publishing house standards, 1986.
4. **GOST 25818−91**. The Fly ash of heat power plants for concretes. Standard specifications. From 01.07.1991. M.: Standards Publishing House, 1992.
5. **GOST 25592−91**. Mixtures ash-slag heat power plants for concretes. Standard specifications. From 01.07.1991. M.: Standards Publishing House, 1992.
6. **GOST 31108−2003**. Cements construction. Standard specifications. From 01.09.2004. M.: State Unitary Enterprise TSPP, 2004.
7. **GOST 20910−90**. Betons temperature-resistant. Standard specifications. From 01.07.1991. M.: Standards Publishing House, 1991.
8. **TS 34−70−10347−92**. Waste ash-slag of heat power plants for a cement making. Standard specifications. M.: NRIcement, 1992.
9. **TS 21−31−2−82**. Ash of heat power plants as raw for manufacturing agloporitovij gravel, a ceramic brick and stones. M.: RNRRBM, 1982.
10. **RBN 185−75**. Technical directions for usage fly ashes and ash-slag mixtures from burning of various aspects of solid fuel for a construction of a roadbed and the device of a base of a road and coatings of highways. From 01.08.1975. M.: USSR, 1976.
11. **GOST 10178−85**. Portland cement and slag-cement. Standard specifications. From 01.01.1987. M.: Standards Publishing House, 1985.
12. **GOST 310−76**. Cements. Methods determining of normal density, hardening times and soundness. From 01.01.1978. M.: Standards Publishing House, 1993.
13. **GOST 25094−94**. Additives active mineral for cements. Test methods. From 01.01.1996. M.: Standards Publishing House, 1996.
14. **GOST 25485−89**. Betons cellular. Standard specifications. From 01.01.1990. M.: Standards Publishing House, 1993.
15. **BN 277−80**. The instruction on manufacture of items from a foam mortar. M.: the System-izdat, 1981.
16. **Directions** for to testing service of harms of heat power plants. Specifications. M.: NRIceramic, 1982.
17. **GOST 9128−97**. Asphaltic concrete mixtures road, air-field and an asphaltic concrete. From 01.01.1999. M.: State Unitary Enterprise TSPP, 1998.